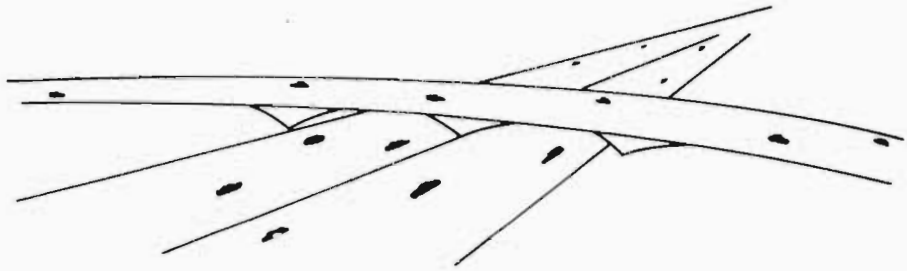

DEPARTMENTAL RESEARCH

Report Number SS 15.13

MAY - 2 1978

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ASPHALT SURFACE TREATMENTS

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWATX78SS15.13		

4. Title and Subtitle	5. Report Date
ASPHALT SURFACE TREATMENTS	October 1977
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
L. E. Schulz and B. R. Russell	SS 15.13

9. Performing Organization Name and Address	10. Work Unit No.
Texas State Department of Highways and Public Transportation Austin, Texas 78763	11. Contract or Grant No. 1-10-77-187
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address Texas State Department of Highways and Public Transportation Transportation Planning Division P. O. Box 5051, Austin, Texas 78763	Special Study Report
	14. Sponsoring Agency Code

15. Supplementary Notes

In cooperation with the United States Department of Transportation, Federal Highway Administration, Washington, D.C. 20590

16. Abstract

This report describes studies of asphalt distribution and quantities provided by spray nozzles of asphalt distributors. The spray nozzles were found to cause uneven distribution and streaking of asphalt placed in a seal coat or surface treatment operation. Tests and specifications were developed or modified for (1) nozzle spray width and (2) a "bucket test" to check asphalt quantities for individual nozzles.

17. Key Words	18. Distribution Statement
Asphalt surface treatments Seal coats Asphalt spray bar Spray bar nozzles Asphalt application	No restrictions

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	22	

Form DOT F 1700.7 (8-69)

D I S C L A I M E R

This report reflects the views of the author who is responsible for the facts presented. The contents do not necessarily reflect the views or policies of the Texas State Department of Highways and Public Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

ASPHALT SURFACE TREATMENTS

by

L. E. Schulz
and
B. R. Russell

District 23
Brownwood

Texas
State Department of Highways and Public Transportation

Special Study

Report Number SS 15.13

October 1977

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CHAPTER I

INTRODUCTION

District 23 uses a modified Kearby method of designing asphalt surface treatments. The design begins with a spreading of aggregate on a measured surface to determine the rate of aggregate for a single rock depth application, similar to Texas Test Method Tex 216-F. The asphalt design rate of application varies according to traffic volume, surface condition, desired embedment, type of asphalt, etc. The design is based on wheel path condition or anticipated wheel application and the asphalt quantities are varied transversely across the roadway depending on the surface condition near the edge of the lanes and between the wheel paths. The basic design is formulated in the office but from visual observations of the roadway surface, however, the design may be slightly adjusted during construction by the field supervisor to fit specific roadway conditions. A form has been prepared to aid in developing and documenting the design. The form allots a portion of space for test records for all tests on bituminous surfaces and is shown in Appendix A.

Our governing specifications require the contractors to provide nozzle sizes that permit variation of the asphalt transversely. Generally, the amount of asphalt is designed for the wheel path and more asphalt is provided in other areas to prevent raveling.

The Asphalt Institute publishes a chart giving the proper nozzle height above the road for the recommended lap of spray. Therefore, nozzle size (and possibly angle) maybe varied for the proper amount of asphalt transversely across the surface. (See Figures 1 and 2)

The 1977 seal coat program consisted of approximately 300 miles let in four contracts. During the initial surfacing on one contract, a considerable amount of streaking was noted. A number of things were

NOZZLE SIZE	NOZZLE SPACING	NOZZLE SLOT ANGLE	NOZZLE HEIGHT ABOVE ROAD	PUMP DISCHARGE - GALS. PER MIN. OR PUMP SPEED	PUMP PRESSURE	APPLICATION RATE GAL. PER SQ. YD.	COVERAGE
1/16"	4"	30° with Spray Bar	12"	5 - 7 gals. per ft. of Spray Bar	--	0.03 gal. to 3.0 gals.	Triple Lap
3/32"	4"	30° with Spray Bar	12"	7 - 10 gals. per ft. of Spray Bar	--	0.03 gal. to 3.0 gals.	Triple Lap
1/8"	4"	30° with Spray Bar	12"	10 - 15 gals. per ft. of Spray Bar	--	0.03 gal. to 3.0 gals.	Triple Lap
3/16"	4"	30° with Spray Bar	12"	12 - 20 gals. per ft. of Spray Bar	--	0.03 gal. to 3.0 gals.	Triple Lap
S36-5	4"	30° with Spray Bar	12"	10 - 15 gals. per ft. of Spray Bar	--	0.06 gal. to 3.0 gals.	Quadruple Lap

Distributor - ETNYRE

F I G U R E 1

SUGGESTED NOZZLE DISTRIBUTION INFORMATION AFTER ASPHALT INSTITUTE

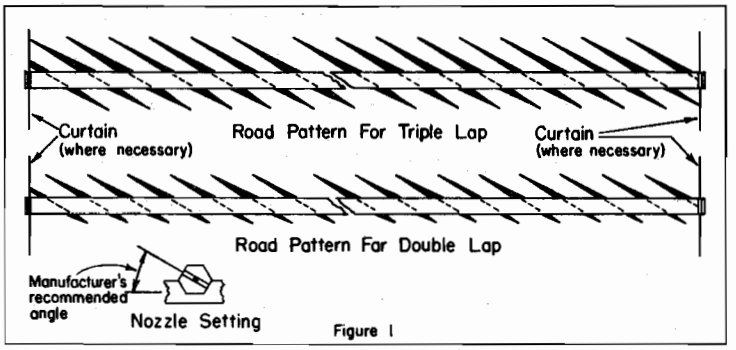


Figure 1

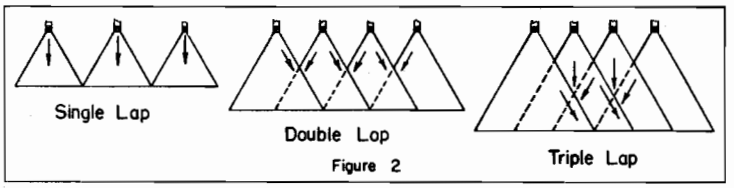
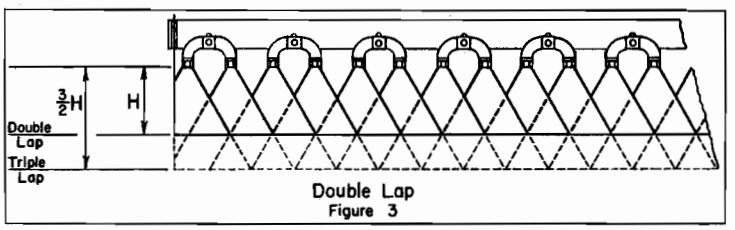
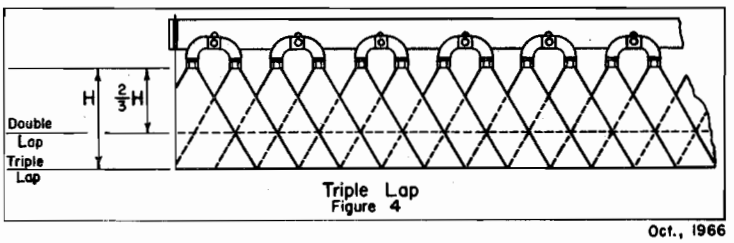


Figure 2



Double Lap
Figure 3



Triple Lap
Figure 4

Oct., 1966

FIGURE 2—SLOT ANGLES AND LAPS FROM THE DHT CONSTRUCTION MANUAL

checked to determine the cause of the streaking. Among these were the height of the spray bar, the slot angle of the nozzle and the pump pressures. After these studies did not provide acceptable clues, we observed the fans on the nozzles were not uniform. All the nozzles were removed from the Etnyre distributor and brought to the district laboratory to check each fan width. The correct width should have been 13.86 inches with a 30 degree slot angle and a triple lap.

C H A P T E R

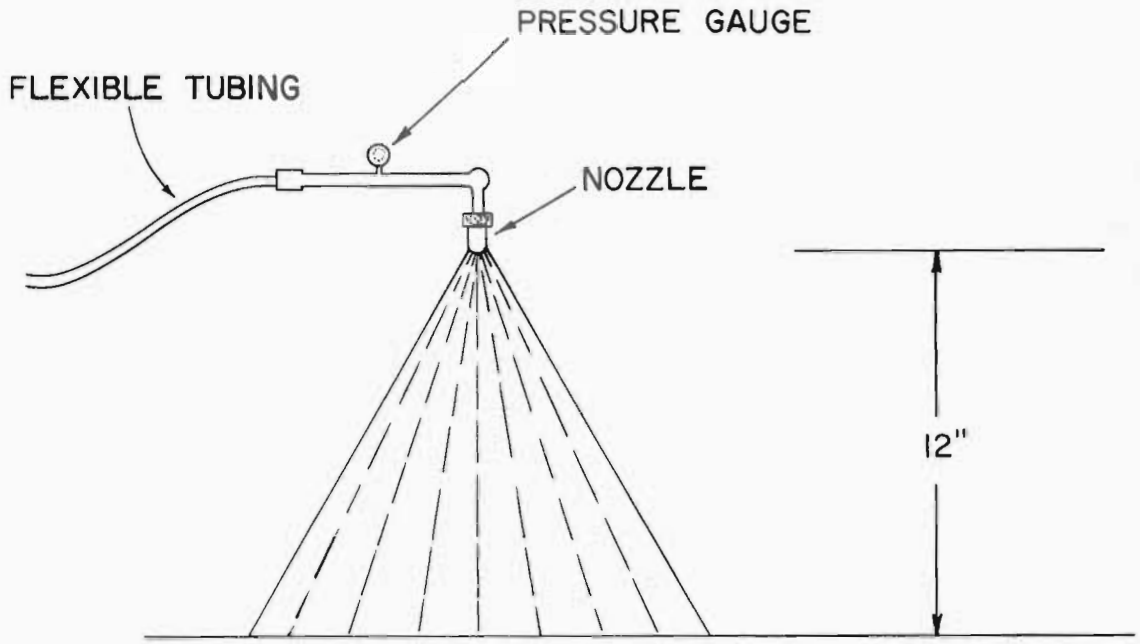
I I

NOZZLE FAN WIDTH TEST

A test was developed to check the nozzles used in asphalt distributors. This test permitted the visual observation of a single nozzle and the resultant distribution characteristics of the nozzle. Figure 3 shows the test method set up. The test permits the nozzle in question to be attached to flexible tubing and the nozzle height to be adjusted. Water is forced through the nozzle at a selected pressure. By placing the nozzle in front of a darkened background and using the correct lighting, the fan distribution can be observed and the fan width measured. Of course water has a different viscosity as compared to the emulsified asphalt being used, however, it has been observed that once a certain water pressure (or water velocity) has been achieved the fan width is constant. This pressure is approximately 5 psi. Also, by observation, the viscosity of water and the heated emulsion are not greatly different. Using these two facts along with the test, the expected spray width can be predicted with a fair degree of accuracy, however, variation between nozzles can certainly be observed.

Each of the nozzles from the distributor were checked using the test described above. The following is the results of this check:

No. of Nozzles	Spray Width
1	10"
5	11"
17	12"
6	13"
3	14"
3	22"



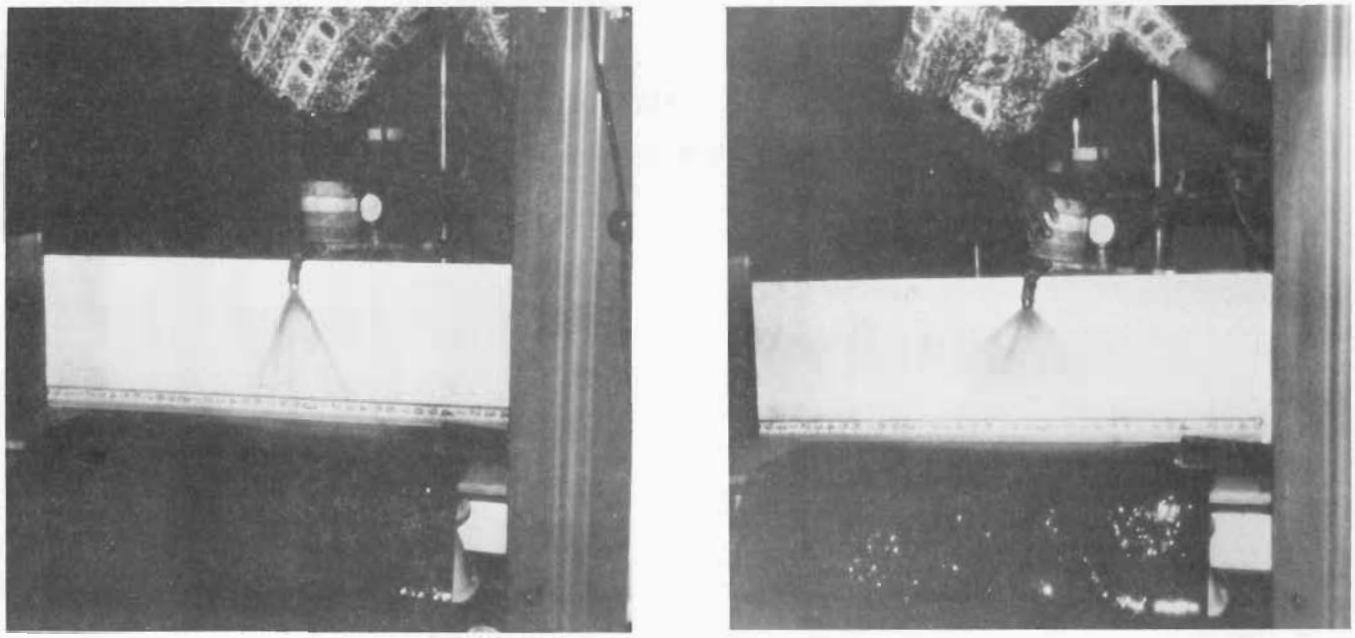


FIGURE 3 - NOZZLE SPRAY WIDTH TEST

Only 9 of the 35 nozzles checked were within 10% of the desired spray width. It is evident that with this spray pattern no uniform transverse distribution could be achieved.

To have better control of the transverse distribution, the district's plan was to provide the contractor with a new set of nozzles for use while applying asphalt in our area. To accomplish this, we purchased fifty 1/8" and fifty 3/32" Etnyre nozzles. These nozzles were checked in our laboratory for uniformity in spray pattern. The correct fan for these nozzles should have been the same as above (13.86") and the following results were found for these new nozzles:

1/8 in. Nozzle		3/32 in. Nozzle	
No. of Nozzles	Spray Width	No. of Nozzles	Spray Width
8	12"	1	14"
26	13"	2	20"
8	14"	4	21"
2	15"	3	22"
1	17"	8	23"
2	18"	24	24"
1	21"	8	26"
1	22"		
1	24"		

The Etnyre Distributor Company that furnished these nozzles was contacted and advised of our finding. They requested that all of the 3/32 in. nozzles be returned to their supply. They in turn would check 50 more 3/32 in. nozzles and furnish good nozzles in their place.

CHAPTER III

BUCKET TEST

In addition to checking the spray width of the nozzles, a test was devised to check the quantity of asphalt delivered by each nozzle along the spray bar. This type of test is not new, for example the "Construction Manual" suggests using strips of thin, foil-backed insulation material and weighing the strips before and after application to determine quantity. However, the district has difficulty in obtaining adequate repeatability in using the insulation material. In the bucket test to be described, discarded triaxial cells previously used in triaxial tests were shortened to an eight-inch height and crushed slightly to form an oval cylinder rather than a cylindrical cylinder. The oval cylinder was fitted with a base or bottom by welding the cylinder to a presized metal plate. This presized metal plate was fabricated from the removed upper portion of the cylinder. In other words, an oval metal container was fabricated (see Figure 4). The hole originally designed to permit lateral pressure was welded closed. Sufficient containers were fabricated so that a container could be placed under each nozzle on the spray bar. Each container was fitted with a plastic bag to catch the asphaltic material and to facilitate the cleaning of the container. A tare weight was obtained for each cylinder. The asphalt in the distributor was heated and circulated. The spray bar was "blown" or the emulsion sprayed for a short period of time and the prepared containers were placed under each nozzle. The containers should be placed in a manner to catch all the emulsion to be emitted in the test without affecting the tare weight. The emulsion was released through the spray bar-nozzles into the containers. The containers were then weighed to determine the asphalt quantity emitted by each nozzle. (see Figure 5) This procedure is normally used to check a distributor entering the district but it could be used at any time.

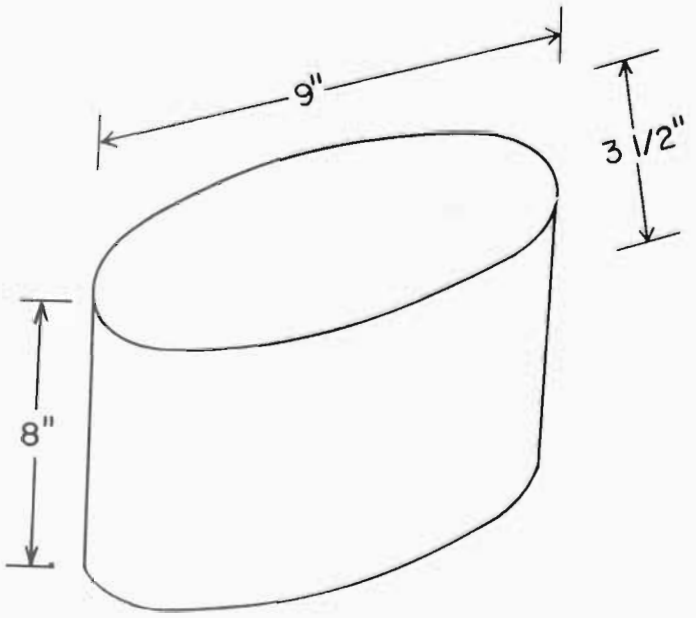


FIGURE 4 - CONTAINER FOR BUCKET TEST

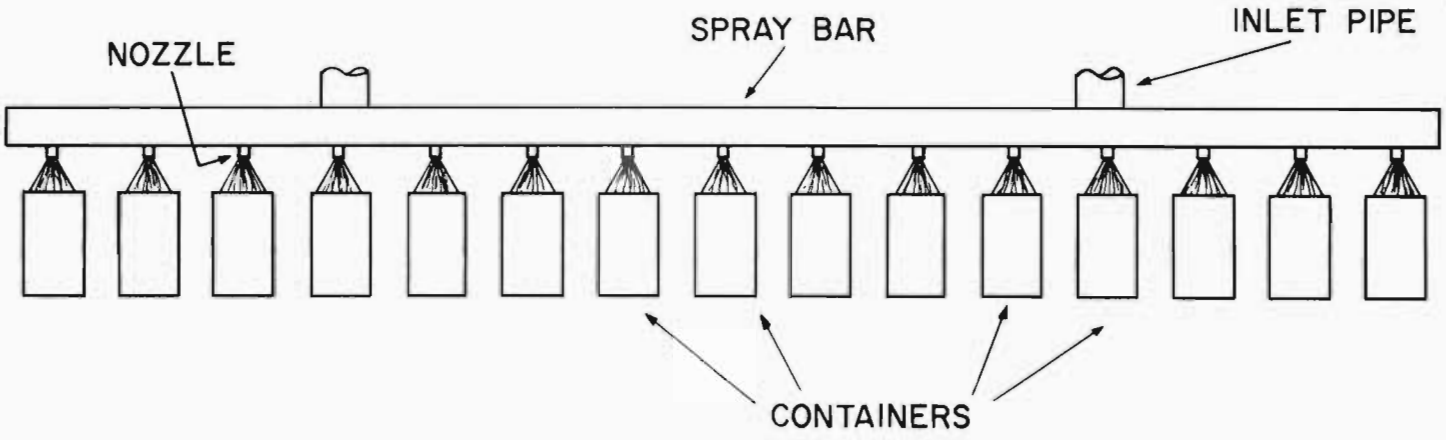


FIGURE 5 - BUCKET TEST

The transverse distribution can be checked using this test to assure the design quantities are being received. However, the calculations should be based on the desired percentage difference between the nozzles in selected regions of the spray bar. These regions may be seven or eight nozzles in the wheel path area as versus the group of nozzles in the region near the lane edges or between the wheel paths. The test is not truly precise and some variation in repeatability of single nozzles exists. An excellent example of the use of this test occurred when comparing the distribution of a long or extended spray bar with a short or nonextended bar. The standard specifications permit a 26-foot spray bar length which generally covers two lanes. Normally most engineers permit only single lane coverage using a bar length of 12 to 15 feet. A test was recently conducted comparing the distribution of a 21-foot bar and a 13-foot bar using the same distributor. The results are shown in Figure 6 with the data obtained shown in Appendix B. The 21-foot bar produced greater quantities in the center 10 to 12-foot portion as compared to the quantities at each end. In other words, for the distributor tested, there was a distinct pressure drop at each end of the bar. However, the distribution rate for the shorter bar shows a smaller variation which is random along the bar.

At present, the district is still considering furnishing nozzles to the contract distributors working in our area. Most of the contractors use Etnyre distributors, and this procedure is believed to be the most practical method of assuring the desired transverse distribution. Observations of the nozzles indicate the defective nozzles have been "milled" or keyed" with slots of varying lengths. When the slot length is shorter (a larger dimension between edge of slot and edge of nozzle) shorter fan widths were found. Longer slot lengths gave longer fan lengths when nozzles were maintained at a constant height. Figure 7 shows this observation. After discussions, the D-4 shops agreed to experiment with several of the nozzles. Several nozzles were re-milled to produce different

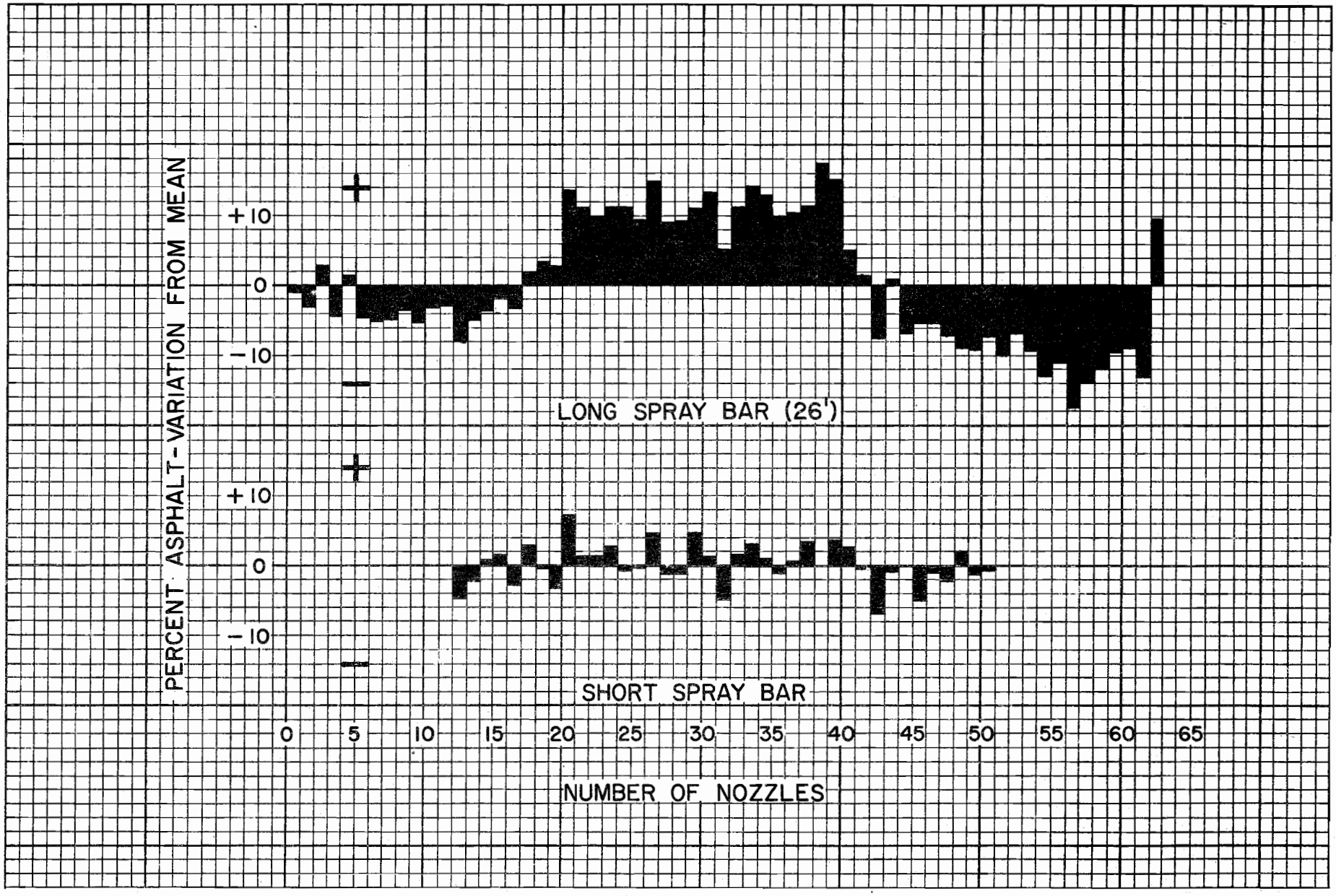


FIGURE 6—EXAMPLE OF PRESSURE DROP WHEN USING LONG SPRAY BAR

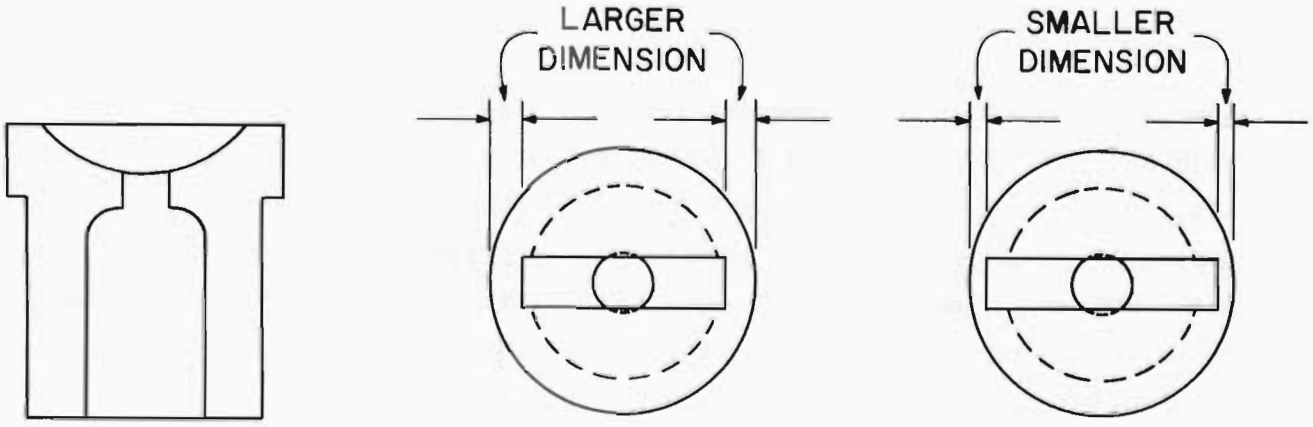


FIGURE 7—SCHEMATIC OF LARGER AND SMALLER FAN WIDTHS

quantities of asphalt. A request has been made to D-4 to obtain nozzles with a 9/64, 5/32, 11/64 and 3/16 - inch slot widths in order that more specific asphalt quantities may be achieved with individual nozzles. The district evaluates and places each nozzle in a fan width group for later use. Therefore, nozzles with correct fan width and output quantities can be selected for the desired transverse distribution.

Referring to fan widths, it is possible to achieve correct spray coverage by combining nozzles of varying spray widths but set at varied and pre-calculated slot angles. However, it would be simpler to use nozzles with a constant spray width as suggested by the Asphalt Institute and set at a constant slot angle. The height may be varied to achieve the desired lap.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Since each job is unique it is necessary that the engineer be given the freedom and authority to conduct the construction processes to produce the best job possible. Therefore, it is believed the present specifications are adequate. However, it is recommended that the engineering staff in District 23 consider the following in seal coat or surface treatment construction:

1. Use of extended spray bars should not be permitted until a check has been made using the Bucket Test. The percent variation from the mean should be random when comparing nozzle output along the bar. The percent variation from the mean of any individual nozzle should not be greater than $\pm$ 10 percent.
2. Distributor nozzles should be checked using the Bucket Test and the percent variation from the mean of any nozzle should not be greater than $\pm$ 10 percent.
3. Distributor nozzles should be checked using the Nozzle Fan Width Test and any individual nozzle should not vary from the desired spray width by more than $\pm$ 10 percent.

In summary, the proper fan and distribution of asphalt distributor nozzles is essential to provide proper lap and quantities at the recommended height and District 23 plans to check all nozzles of the distributors used in the area prior to the application of asphalt. Perhaps with increased attention to nozzles along with the improved design procedures available longer lasting and better surfaces will result.

A P P E N D I X
A

SURFACING TEST REPORT FORM

Form Dist. 23-17C Rev.
File F.8-1

SURFACING TEST REPORT
(Penetration and A.C.P.)

Sample No._____ Specification Item_____ Project_____

Type of Material_____ Highway_____

Producer_____ County_____

Date Sampled_____ Date Reported_____

Sieve Analysis

Retained On	Wt.	%	Spec.
7/8" Sieve			
3/4" Sieve			
5/8" Sieve			
1/2" Sieve			
3/8" Sieve			
1/4" Sieve			
#4 Sieve			
#10 Sieve			
Total			

BULK SPECIFIC GRAVITY (201F)(Dry)

$$Sp.Gr. = \frac{X_1}{X+Y-Z} = \frac{\qquad}{+\quad -} = \_\_\_\_$$

SAND EQUIVALENT (203F)

$$S.E. = \frac{\text{Sand Reading}}{\text{Clay Reading}} \times 100$$

$$S.E. = \frac{\qquad}{} \times 100 = \_\_\_\_$$

BULK SPECIFIC GRAVITY (Lt Wt)(433A)(Dry)

$$Sp.Gr. = \frac{X}{X+Z-Z} = \frac{\qquad}{+\quad -} = \_\_\_\_$$

AGGREGATE BOARD TEST (S.Y./C.Y.)

	#1	#2	#3	Avg.
Pounds = Q=				

$$S = \frac{27\ U.Wt.}{Q} = \frac{27 \times \qquad}{} = \_\_\_\_ \text{ Actual}$$

$$\text{Eft. Mat thickness} = \frac{36}{S.\ (Act)} = \frac{\qquad}{} = \_\_\_\_$$

MOISTURE

$$\% = \frac{W.W.-D.W.}{D.W.} \times 100 = \frac{\qquad}{} \times 100 = \_\_\_\_\%$$

ASPHALT DESIGN

$$A = \frac{7.48eQ}{U.Wt.}\left(1 - \frac{U.Wt.}{62.4G}\right)$$

PERCENT EMBEDMENT = e = _____

$$A = \frac{7.48 \times \quad \times}{} \left(1 - \frac{\qquad}{62.4 \times}\right)$$

A = _____ Gal/SY (Computed Asphalt Cement)

PERCENT EMBEDMENT = e = _____

$$A = \frac{7.48 \times \quad \times}{} \left(1 - \frac{\qquad}{62.4}\right)$$

A = _____ Gal/SY (Computed Asphalt Cement)

DELETERIOUS MATTER (217F Part I)

$$\% = \frac{D}{W} \times 100 = \frac{\qquad}{} \times 100 = \_\_\_\_\%$$

Specification Requirement = _____% Max.

DECANTATION (217F Part II)

$$\% \text{ Loss} = \frac{B-C}{B} \times 100 = \frac{\qquad}{} \times 100 = \_\_\_\_\%$$

Specification Requirement = _____% Max.

UNIT WEIGHT (#/C.Y.) Dry (404A)

	#1	#2	#3
Meas.+Mat'l. =			
Tare Weight =			
Net Weight =			
Avg. Net Wt. =			

U. Wt. = FW = _____ x _____ = _____

Specification Requirement = _____ to _____

% CRUSHED PARTICLES BY WEIGHT (413A)

$$\% = \frac{W_1}{W_T} \times 100 = \frac{\qquad}{} \times 100 = \_\_\_\_\%$$

Specification Requirement = _____% Min.

% CRUSHED PARTICLES BY COUNT (413A)

$$\% = \frac{CP}{TP} \times 100 = \frac{\qquad}{} \times 100 = \_\_\_\_\%$$

Specification Requirement = _____% Min.

PRESSURE SLAKING (431A)

$$P.S.V. = \frac{\text{Wt. of -40 Matl}}{\text{Wt. of Total Sample}} \times 100$$

$$P.S.V. = \frac{\qquad}{} \times 100 \quad \_\_\_\_$$

Specification Requirement = _____% Max.

VISCOSITY (513A)

V = _____ Seconds

Specification Requirement = _____ to _____

Sampled By_____
Signature Date

Tested By_____
Signature Date

Approved By_____
Signature Date

ASPHALT: Type and Grade_____ Producer_____

Ref. No.	Crse.	Width	Location*	Sta. to Sta.		ADT Per Lane	Hunger Factor Code#

*Operation I, Rt. Lane, Lt.Shoulder on Operation II, Underseal etc.

ASPHALT AND AGGREGATE RATE DETERMINATION

DESCRIPTION	REFERENCE NO.									
	1	2	3	4	5	6	7	8	9	10
Computed Asphalt Rate										
Adj. for Vol. Change o- o										
Adj. for Traffic										
Adj. for Hunger Factor										
Adj. for Emuls. Asphalt										
APPLICATION RATE										
Computed Aggregate Rate										
DISTRIBUTION RATE										

VPD Per Lane	Adj. Gal/S.Y.
< 100	+0.06
100 - 250	+0.05
250 - 400	+0.04
400 - 600	+0.03
600 - 800	+0.02
800 -1000	+0.01
1000 -1500	0
1500 -2000	-0.01
> 2000	-0.02

#HUNGER FACTORS

H.F.C.	Hun.Fac.	Description
H-1	-0.03	Prime is black and waxy - Not penetrated
H-2	0	Prime is dark brown - Penetrated well
H-3	+0.02	Prime is light brown - insufficient amount
H-4	-0.06	Flushed, slightly bleeding surface
H-5	-0.03	Smooth, nonporous surface
H-6	0	Slightly porous, slightly oxidized surface
H-7	+0.03	Slightly pocked, porous, oxidized surface
H-8	+0.06	Badly pocked, porous, oxidized surface
H-9	+0.09	Very dry, eroded, severely cracked, pitted and oxidized surface.

FOR FIELD USE ONLY

Intended Application Rates

(Insert Rates you intended to use)

Ref. No.	1	2	3	4	5	6	7	8	9	10
Asphalt										
Aggregate										

REMARKS:

File F.8-2

A P P E N D I X

B

SPRAY BAR PRESSURE DROP TESTS

EXAMPLE OF PRESSURE DROP WITH LONG SPRAY BAR

LAB. NO.:	77-234-160 Job	DISTB:	Etnyre
DATE:	July 22, 1977	MODEL:	BT-HL
PROJECT:	TQF 767(9)	SERIAL NO.:	J4481
HIGHWAY:	U.S. 190	NOZZLE:	20' (21')
COUNTY:	McCulloch	CONTRACTOR:	J. H. Strain & Sons, Inc.

Bucket #	T. W.	Bucket & Asphalt	Asphalt	%
1	1286	2819	1533	- .7
2	1230	2728	1498	- 3.0
3	1269	2857	1588	+ 2.8
4	1261	2741	1480	- 4.1
5	1276	2844	1568	+ 1.6
6	1351	2831	1480	- 4.1
7	1283	2746	1463	- 5.2
8	1228	2694	1466	- 5.1
9	1285	2771	1486	- 3.8
10	1302	2768	1466	- 5.1
11	1212	2708	1496	- 3.1
12	1267	2768	1501	- 2.8
* 13	1218	2639	1421	- 8.0
14	1422	2895	1473	- 4.6
15	1260	2746	1486	- 3.8
16	1423	2938	1515	- 1.9
17	1232	2724	1492	- 3.4
18	1461	3036	1565	+ 1.4
19	1329	2924	1595	+ 3.3
20	1236	2818	1582	+ 2.5
21	1315	3071	1736	+13.7
22	1244	2963	1719	+11.3
23	1271	2973	1702	+10.2
24	1223	2941	1718	+11.3
25	1296	3016	1720	+11.4
26	1290	2986	1696	+ 9.8
27	1393	2159	1766	+14.4
28	1406	3080	1674	+ 8.4
29	1197	2880	1683	+ 9.0
30	1307	3012	1705	+10.4
31	1273	3120	1707	+13.1
32	1231	2865	1634	+ 5.8
33	1275	2995	1720	+11.4
34	1291	3051	1760	+14.0
35	1395	3131	1736	+12.4
36	1404	3101	1697	+ 9.9
37	1305	3008	1703	+10.3

Tank Cop. 2317

* No. 1 on Lab. No. 77-233-160 Job

EXAMPLE OF PRESSURE DROP WITH LONG SPRAY BAR
(continued)

Bucket #	T. W.	Bucket & Asphalt	Asphalt	%
38	1304	3024	1720	+11.4
39	1310	3118	1808	+17.1
40	1263	3042	1779	+15.2
41	1278	2895	1617	+ 4.7
42	1264	2829	1565	+ 1.4
43	1407	2834	1427	- 7.6
44	1433	2988	1555	+ .7
45	1285	2726	1441	- 6.7
46	1310	2768	1458	- 5.6
47	1292	2748	1456	- 5.7
48	1257	2694	1437	- 6.9
49	1293	2708	1415	- 8.4
50	1241	2646	1405	- 9.0
51	1277	2710	1433	- 7.2
52	1310	2700	1390	-10.0
53	1311	2751	1440	- 6.7
54	1250	2647	1397	- 9.5
55	1398	2741	1343	-13.0
56	1401	2775	1374	-11.0
57	1286	2558	1272	-17.6
58	1257	2587	1330	-13.9
59	1312	2673	1361	-11.9
60	1304	2699	1395	- 9.7
61	1226	2635	1409	- 8.7
62	1327	2670	1343	-13.0
63	1226	2618	1392	9.8
64	1306			
65	1432			
66	1252			
67	1274			
68	1212			
69	1310			
70	1388			
71	1394			
72	1378			
73	1289			
74	1403			
75	1217			
76	1261			
77	1274			
78	1412			

EXAMPLE OF PRESSURE DROP USING SHORT SPRAY BAR

LAB. NO.:	77-233-160 Job	DISTB.:	Etnyre
DATE:	July 22, 1977	MODEL:	BT-HL
PROJECT:	TQF 767(9)	SERIAL NO.:	J4481
HIGHWAY:	U.S. 190	NOZZLE:	1/8
COUNTY:	McCulloch	CONTRACTOR:	J. H. Strain & Sons, Inc.

Bucket #	T. W.	Bucket & Asphalt	Asphalt	%
38	1304	2856	1552	- 4.5
39	1310	2898	1588	- 2.3
40	1263	2894	1631	+ .4
41	1278	2929	1651	+ 1.6
42	1264	2849	1585	- 2.5
43	1407	3071	1664	+ 2.4
44	1433	3055	1622	- .2
45	1285	2857	1572	- 3.3
46	1310	3048	1738	+ 7.0
47	1292	2932	1640	+ .9
48	1257	2900	1643	+ 1.1
49	1293	2956	1663	+ 2.3
50	1241	2859	1618	- .4
51	1277	2898	1621	- .2
52	1310	3003	1693	+ 4.2
53	1311	2925	1614	- .7
54	1250	2858	1608	- 1.0
55	1398	3095	1697	+ 4.4
56	1401	3046	1645	+ 1.2
57	1286	2839	1553	- 4.4
58	1257	2903	1646	+ 1.3
59	1312	2982	1670	+ 2.8
60	1304	2941	1637	+ .7
61	1226	2834	1608	- 1.0
62	1327	2953	1626	+ .1
63	1226	2879	1653	+ 1.7
64	1306	2486	1180	-----
65	1432	3116	1684	+ 3.6
66	1252	2915	1663	+ 2.3
67	1274	2894	1620	- .3
68	1212	2721	1509	- 7.1
69	1310	2921	1611	- .9
70	1388	----	----	-----
71	1394	2935	1541	- 5.2
72	1378	2988	1610	- .9
73	1289	2878	1589	- 2.2
74	1403	3060	1657	+ 2.0
75	1217	2817	1600	- 1.5
76	1261	2874	1613	- .7

Tank Cop. 2317